This process has the characteristic that the lead plate 4 connected to the electrode assembly 1 can be reliably welded and fixed to the bottom plate of the external case 5. However, a battery of this configuration must be provided with a center hole in the middle of the electrode assembly 1, and this center hole must have a diameter larger than the electrode rod for weld connection. Therefore, the actual volume of the electrode assembly is reduced and the battery's capacity is decreased. Increasing battery capacity by reducing the size of the electrode assembly center hole may be considered, but when center hole size is reduced, fitting the electrode rod in the center hole becomes a problem.

Technology for connecting a lead plate to the bottom of an external case by laser welding from outside the case has been developed to eliminate the drawbacks of a battery with the configuration described above (Japanese Non-examined Patent Publications No. 4-162351 issued on June 5,1992 and No. 8-293299 issued on Nov. 5,1996). These and other disclosures cite batteries which do not use an electrode rod for weld connection. As shown in Fig. 2, an energy beam such as a laser is applied to the bottom plate 25A of the external case 25 from outside the case. The energy beam fuses a portion of the bottom plate 25A and the lead plate 24 to weld and attach the lead plate 24 to the bottom plate 25A.

As shown in Fig.2, there is no need to provide a center hole in the electrode assembly 21 of a battery in which an energy beam, such as a laser beam, is applied from outside the case to weld the lead plate to the bottom plate. Consequently, this type of battery has the characteristic that the actual electrode assembly volume and battery discharge capacity can be increased. However, in this type of battery in which the lead plate is ~~weld-attached~~ welded to the bottom plate from outside the external case, and attachment of the lead plate can fail to ~~reliably weld attached to the~~ welds bottom plate. For example, with the electrode assembly inserted into the external case, if the lead plate is separated from the bottom plate, the bottom plate of the external case will fuse but the lead plate will not, and the energy

beam will not be able to reliably ~~weld attach~~ weld the lead plate to the bottom plate. In addition, if foreign material or contamination is between the lead plate and bottom plate, the energy beam will also fail to make a reliable ~~weld attachment~~ weld. In particular, whether or not the lead plate is ~~weld attached~~ welded to the bottom plate and what kind of attachment is made, cannot be determined from outside this type of battery. Since evaluation of battery quality is difficult, it is extremely important to make weld attachments more reliably.

This invention was developed to solve these types of problems. It is thus a primary object of the present invention to provide a battery that can reliably ~~weld attach~~ weld a lead plate to an external case.

The above and further objects and features of the invention will more fully be apparent from the following detailed description with accompanying drawings.

Summary of the Invention

The battery has an electrode assembly inserted into a cylindrical external case. A lead plate connected to the electrode assembly is ~~weld attached to~~ welded the inner surface of the external case by an energy beam applied from outside the external case.

Further, the battery of the present invention is provided with a projection which projects from the inner surface of the external case. An energy beam is applied to the projection from outside the external case to weld attach the inner surface of the projection to the lead plate.

A battery of this configuration has the characteristic that the lead plate can be reliably ~~weld attached~~ welded to the external case. This is because the projection in the external case makes reliable contact with the lead plate. The external case and lead plate can be reliably ~~weld attached~~ welded by application of an energy beam, such as a laser, to the projection which has its inner surface in contact with the lead plate. In particular, a battery, in which the lead plate and

external case can be reliably contacted and welded, also reliably prevents separation of the lead plate and external case due to mechanical shock.

In the battery of the present invention, the projection is disposed in a still more preferable arrangement for contact and weld ~~attachment~~ to the lead plate by curving the projecting surface to its center or by making a conical shaped projection.

Further, the lead plate of the battery can be provided with a flexible deforming piece, and the projection in the external case can be ~~weld attached~~ welded to this flexible deforming piece. In addition, the flexible deforming piece can jut outwards towards the projection in the external case to further improve connection of the lead plate and the external case.

Anti-corrosive coating can be used to coat the region of the battery where the energy beam is applied from outside the external case. This effectively prevents corrosion of the region of energy beam application, and contact resistance problems can be avoided via the anti-corrosive coating.

Brief Description of the Drawings

Fig. 1 is a cross section view showing a prior art battery fabrication method.

Fig. 2 is a cross section view showing another fabrication method of a prior art battery.

Fig. 3 is a cross section view showing an embodiment of a battery of the present invention.

Fig. 4 is a cross section view showing the bottom of the external case of the battery shown in Fig. 3.

Fig. 5 is a cross section view showing the bottom of the external case of a battery of another embodiment of the present invention.

Fig. 6 is a bottom view of the external case shown in Fig. 4.

Fig. 7 is a cross section view showing the bottom region of a battery of

another embodiment of the present invention.

Fig. 8 is a plan view showing the lead plate contained at the bottom of the battery shown in Fig. 3.

Fig. 9 is a plan view showing the lead plate contained at the top of the battery shown in Fig. 3.

Fig. 10 is an enlarged cross section view of a lead plate.

Fig. 11 is a cross section view showing the disposition of a lead plate for weld ~~attachment to~~ welding an electrode assembly.

Fig. 12 is a front view showing another type of lead plate for incorporation into a battery of the present invention.

Detailed Description of the Invention

The battery shown in Fig. 3 is a rechargeable battery such as a nickel hydride battery, a nickel cadmium battery, or a lithium ion battery, and is provided with a circular cylindrical external case 35, an electrode assembly 31 for insertion into this external case 35, and lead plates 33, 34 for connecting the electrode assembly 31 to the external case 35. Although the external case of the battery shown in Fig. 3 has a circular cylindrical shape, the external case of the battery of the present invention is not limited to a circular cylindrical shape. Although not illustrated, the external case may also take on, for example, a rectangular cylindrical shape or an elliptical cylindrical shape.

The external case 35 is made of iron or steel with nickel plated surfaces. The material for the external case 35 is the optimum metal selected considering the type of battery and its characteristics. For example, the external case 35 may also be made of stainless steel, aluminum, or aluminum alloy. The open region at the upper end of the metal external case 35 is sealed closed in an airtight fashion by the sealing lid 37. The sealing lid 37 of Fig. 3 is fixed in place on the external case 35 in an electrically insulating fashion by a caulked junction structure. The sealing lid may also be fixed on the external case in an

airtight fashion by a method such as laser welding. This configuration of sealing lid insulates and holds an electrode stationary. The sealing lid 37 fixes one terminal of the battery in place.

As shown in Figs. 3 and 4, the external case 35 is provided with a projection 35a in the region where the lead plate 34 is welded and fixed to the external case 35. A projection 35a is provided on the bottom plate 35A of the external case 35 of the battery shown in the figures, and the lead plate 34 is welded ~~weld attached~~ to this projection 35a. As shown in the bottom view of Fig. 6, the external case 35 is provided with a projection 35a at the center of the bottom plate 35A. An external case 35 provided with a projection 35a in this location has the characteristic that the location for welding ~~weld attachment~~ of the lead plate 34 by an energy beam operation such as laser welding can be easily and accurately aligned. This is because the location for energy beam weld attachment of the lead plate 34 does not change regardless of the position to which the external case 35 has rotated. However, there is no requirement to locate the projection at the center of the bottom plate. Further, the projection is not required to be provided on the bottom plate. For example, as shown in Fig. 7, the projection may also be provided on a side-wall of the external case 75. However, regardless of where the projection is provided, the lead plate 74 is welded ~~weld attached~~ to the projection 75a.

The outside diameter of the projection 35a is designed to an optimum value considering the area of the weld ~~attach~~. If the diameter of the projection 35a is made small, the top of the projection can be reliably welded ~~weld attached~~ to the lead plate. However, if the projection diameter is too small, the weld ~~attach~~ area between the lead plate and external case becomes smaller.

Making the projection 35a jut high up from the inner surface of the external case 35 improves the situation for welding ~~weld attachment~~ of the projection 35a and the lead plate 34. However, making the projection 35a project high upwards pushes the electrode assembly 31, which inserts into the external case 35, upwards. Consequently, this makes it necessary to reduce the height

of the electrode assembly 31, and this reduces the real capacity of the electrode assembly.

As shown in Fig. 4, the projection 35a is shaped with its convex surface curved around the central protrusion. Or, as shown in Fig. 5, the projection 55a protrudes outward in a conical shape. In a battery with a projection having a protruding surface in one of these configurations, the lead plate 54 contacts the projection 55a without gaps or voids. Therefore, a battery of this type has the characteristic that the lead plate 54 and projection 55a can be more reliably weld attached. However, the protruding surface of the projection 55a may also be planar.

The electrode assembly 31 is a laminate of a positive electrode plate, a negative electrode plate, and a separator in between. The battery shown in Fig. 3 has a stack of positive electrode plate, negative electrode plate, and intervening separator rolled together. This spiral shaped electrode assembly 31 is inserted into the circular cylindrical external case 35. The spiral electrode assembly 31 may also be pressed from both sides to distort it into an elliptical shape for insertion into an elliptical shaped or rectangular shaped external case. Further, an electrode assembly for insertion into a square cylindrical external case can also be fabricated by cutting a plurality of positive electrode plate and negative electrode plate sheets, and stacking them with separator in between.

The electrode assembly 31 has lead plates 33, 34 connected to the positive and negative electrode plates. The lead plates 33, 34 are disposed at the top and bottom of the electrode assembly 31 and are connected to the positive and negative electrode plates. As shown in Fig. 3, positive and negative electrode plate core material projects upward and downward from the electrode assembly 31, and the lead plates 33, 34 are connected to these projections. In the electrode assembly 31 in the figures, the electrode plate 34 disposed at the bottom of the electrode assembly 31 is connected to the external case 35. The electrode plate 33 disposed at the top of the electrode

assembly 31 is connected to the sealing lid 37.

As shown in Figs. 8 and 9, the lead plates 33, 34, which connect to the top and bottom of the electrode assembly 31, are cut from metal plate in disk shapes smaller than the inside of the external case 35. As shown in Fig. 9, the lead plate 33 which connects to the top surface of the electrode assembly 31 has a lead strip 33A projecting from its periphery. The lead strip 33A connects to the sealing lid 37, which is electrically insulated from, and attaches to the open region of the external case 35. A lead plate 33 of the shape shown in Fig. 9 may also be used to connect the bottom surface of the electrode assembly to a side-wall of the external case.

As shown in the cross section view of Fig. 11, these types of lead plates 33, 34 are pressed against the electrode assembly 31 via a welding electrode 38, and reliably connected by resistive electric welding. A plurality of holes 39 are opened through the lead plates 33, 34 shown in Figs. 8 and 9 to reliably connect the lead plates 33, 34 electrically to the electrodes of the electrode assembly 31. As shown in the enlarged cross section view of Fig. 10, projections 310 are provided extending downward from the periphery of the holes 39 in the lead plates 33, 34. The projections 310 are connected to the electrode plates of the electrode assembly. Further, as shown in Fig. 9, the lead plate 33, which connects to the top of the electrode assembly 31, is provided with slits 313 on either side of a center hole 311 to reduce unnecessary electric current during resistive electric welding.

As shown in Fig. 8, the lead plate ~~33~~ 34, which connects to the ~~top~~ bottom of the electrode assembly 31, is provided with a U-shaped cut-out 312, and a flexible deforming piece 34A is provided inside this cut-out 312. The flexible deforming piece 34A protrudes outwards towards the projection 35a in the external case 35. The flexible deforming piece 34A is approximately at the center of the lead plate 34, and is ~~weld attached~~ welded to the external case 35 projection 35a.

Since lead plates 33, 34 in a battery of this configuration can connect to the electrode assembly 31 at a plurality of locations, the battery has excellent

high current characteristics. This is because internal resistance can be made small. Further, a battery of this configuration also has the characteristic that the lead plate 34 can be reliably ~~weld attached~~ welded to the bottom plate 35A via an energy beam. This is because the electrode assembly 31 can be inserted into the external case 35, and the lead plate 34 can be put in intimate contact with the bottom plate 35A of the external case.

However, the battery of the present invention is not limited to a lead plate, which connects the electrode assembly to the external case, according to the structure described above. For example, the lead plate may also have a band shape as shown in Fig. 12. This lead plate 124 connects to exposed core material of an electrode, extends out from the bottom of the electrode assembly, and its end ~~weld attaches~~ welds to the inner surface of the external case. This type of lead plate 124 may also extend out from the side of the electrode assembly and ~~weld attach~~ weld to a side-wall of the external case as shown in Fig. 7.

The lead plate 34 is ~~weld attached~~ welded to the inner surface of the external case 35. An energy beam such as a laser beam or an electron beam, etc. is used as a method of weld-attaching the lead plate 34. The energy beam fuses both the external case 35 and the lead plate 34 to ~~weld attach~~ weld the lead plate 34 and the external case 35. As shown in Fig. 4, a laser beam is ~~shined~~ directed at a wide region, which includes the entire projection 35a, to weld attach the lead plate 34 and the external case 35.

When an energy beam such as a laser beam is applied to the outer surface of the external case 35, corrosion resistant metal plating, which coats the surface of the external case 35, loses its effectiveness. Consequently, the region of energy beam application can easily corrode. This drawback can be eliminated by coating the region of energy beam application with an anti-corrosive coating 36, as shown in the enlarged portion of the cross section view of Fig. 3. However, when anti-corrosive coating 36 is applied to the bottom surface of the external case 35, the anti-corrosive coating 36 can be the cause

of contact resistance during battery operation. This is because non-conducting organic coating material is used as the anti-corrosive coating 36. This drawback can be eliminated by mixing conductive material such as carbon or metallic powder into the anti-corrosive coating 36.

The anti-corrosive coating 36 can be sprayed in aerosol form or applied using a paint brush. Further, the anti-corrosive coating 36 may also be sprayed from a miniature nozzle according to ink-jet technology. The ink jet method has the characteristic that a precise thickness of anti-corrosive coating can be applied to the precise location of energy beam application. In addition, the anti-corrosive coating 36 can also be applied at the same time the date of manufacture and the usable date are printed on the external case of the battery by ink-jet.

[Embodiments]

[Embodiment 1]

Nickel cadmium batteries were fabricated by the following process, and lead plate to external case connections were tested. An external case provided with a projection 35a in the center of the bottom surface, as shown in Fig. 4, was used. The projection 35a was shaped with its convex surface curved around the central protrusion. The outside diameter of the projection 35a was approximately 2mm, the height of the projection was 0.2mm, and the radius of curvature of the protruding surface was 15mm.

As a lead plate 34, which connects to the bottom surface of the electrode assembly 31, a configuration provided with a flexible deforming piece 34A, as shown in Fig. 8, was used. A flexible deforming piece 34A, which protruded outwards approximately 0.2mm was used.

An electrode assembly rolled into a spiral shape with a separator between electrodes and lead plates 33, 34 welded ~~weld attached~~ to both ends was inserted in the external case 35 with the above configuration. Lead plates 33, 34 with a plurality of holes 39 and projections 310 provided at the periphery of the holes 39 were used. The electrode assembly was inserted into the external

case, a laser was applied to the indentation corresponding to the projection 35a provided in the bottom surface of the external case, and the lead plate 34 was ~~weld attached to~~ welding the external case 35. As a coating on the laser weld region at the outer bottom surface of the external case, Hitachi Manufacturing LTD. [JP-K28] was applied. After ~~weld attach~~ing the lead plate 33 connected to the top surface of the electrode assembly to the sealing lid 37, electrolyte was added, and the opening in the external case was closed off with the sealing lid 37 to complete fabrication of a nickel cadmium battery.

[Embodiment 2]

Nickel cadmium batteries were fabricated by the same process as embodiment 1, except the lead plate connected to the bottom surface of the electrode assembly had no flexible deforming piece. The region of the lead plate for ~~weld attachment~~ welding to the external case was planar for this battery.

[Comparison Example]

Nickel cadmium batteries were fabricated by the same process as embodiment 1 except the bottom surface of the external case had no projection.

The following shows comparison of lead plate to external case weld ~~attach~~ success ratios for batteries fabricated as described above.

Batteries of Embodiment 1	100%
Batteries of Embodiment 2	98%
Batteries of the Comparison Example	97%

From these test results, batteries of embodiment 1 and embodiment 2 had lead plates and external cases reliably connected. In particular, there was no failure of the weld between the lead plate ~~to~~ and the external case ~~weld attach~~ for batteries of embodiment 1.

As this invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them,